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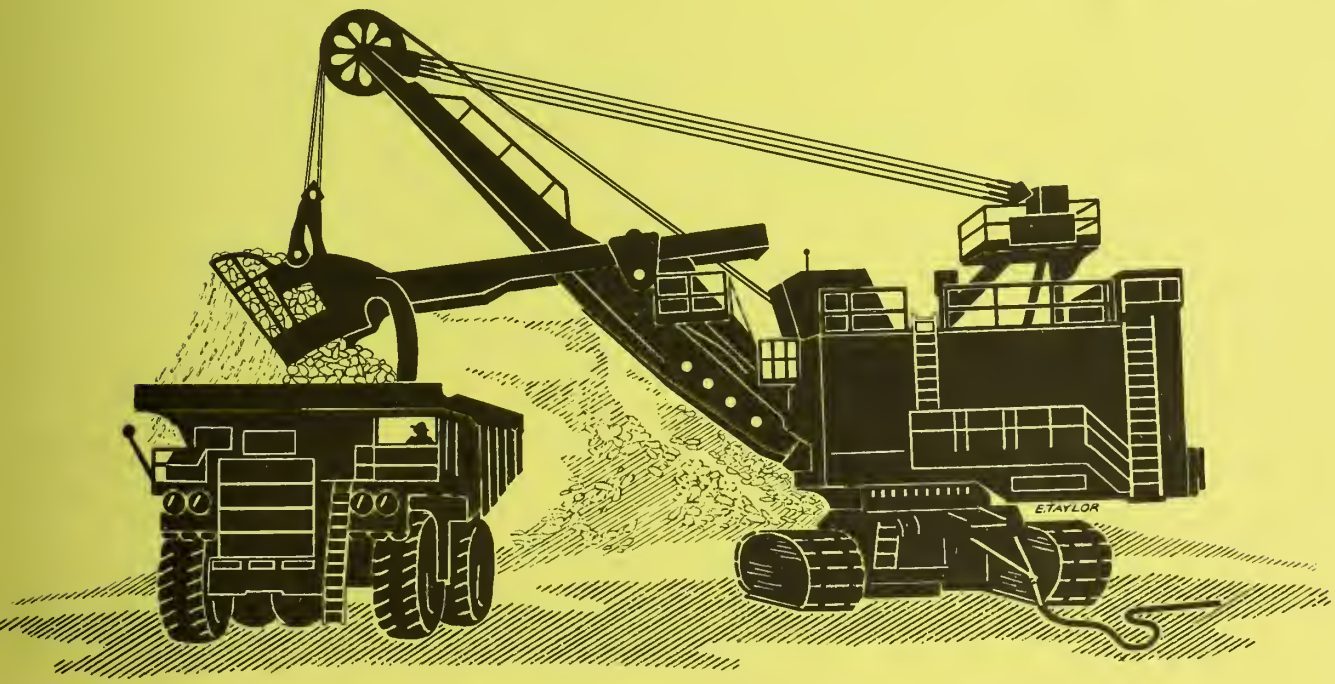
MINERAL COMMODITY REPORT
—— POTASH ——

1984

Part I adapted from
the U.S. Bureau of Mines publication,
Mineral Commodity Summaries, 1984



CALIFORNIA DEPARTMENT OF CONSERVATION
DIVISION OF MINES AND GEOLOGY

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SPECIAL PUBLICATION 70

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CALIFORNIA DEPARTMENT OF CONSERVATION
DIVISION OF MINES AND GEOLOGY
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INTRODUCTION

This report on the availability and demand for potash in California, the United States, and the world is one in a series of Mineral Commodity Reports prepared by the California Division of Mines and Geology (CDMG) to describe commodities of significance to California and the nation.

This mineral information report is in two parts: (1) United States and world-wide mineral-statistic information and economic analysis, adapted directly from the U.S. Bureau of Mines Mineral Commodity Summaries (1983); and (2) a section on the California minerals industry, prepared by CDMG. The U.S. Bureau of Mines presents the earliest Government estimates of non-fuel mineral-industry data, including world resource data provided by the U.S. Geological Survey.

Potassium (commonly referred to as its oxide, "Potash", K_2O) is essential to all forms of plant and animal life. About 95 percent of the potassium compounds produced in the world are utilized as fertilizers; the remaining 5 percent are used in manufacturing drugs, dyes, and chemical reagents (U.S. Bureau of Mines, 1970).

Potassium is a chemically active metal. Because of its highly active characteristics, it is never found in its pure state in nature, but is always combined with one or more other elements. The term "Potash" comes from "pot ashes," which in colonial days in America were the primary source of potassium for fertilizers and for soap, glass, gunpowder, and other industrial uses. Today, all potash is derived from (1) crystalline deposits of saline rocks of marine origin containing sylvite, langbeinite, and related potassium minerals and (2) concentrated brines from wells or in relict lakes and lacustrine sediments of continental origin in arid regions. California's potash production is from potassium-bearing brines at Searles Lake in San Bernardino County.

In 1983, approximately 75 percent of the 5,170,000 tons of potash utilized in the United States was imported from foreign sources, principally Canada (93%), Israel (5%), and others (2%). United States production amounted to 1,300,000 tons; of this total, California's production was less than 13 percent.

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PART I: UNITED STATES AND WORLDWIDE

1. UNITED STATES PRODUCTION AND USE

Potash: The value of U.S. production of marketable potash, f.o.b. mine, in 1983 was about $190 million. Potash production was centered in southeastern New Mexico where six companies operating six mines by conventional mining of bedded deposits, produced 87% of the U.S. total. One mine closed on January 24, 1983, for an extended period of time due to low potash prices and to reduce inventories while several others closed for several months to reduce inventories. All other mines were operated at reduced levels. One mine in Utah recovered potash by solution mining underground and pumping it to the surface for solar evaporation and flotation. Two plants in Utah and one in California recovered potash from salt lakes or subsurface brines. Coproducts were boron compounds and salt cake from brines in California and salt, salt cake, and magnesium chloride brine from the Great Salt Lake in Utah. About 95% of the U.S. output was used directly in the fertilizer industry and about 5% was used in the chemical industry. Most potash was produced as potassium chloride (muriate of potash). Potassium sulfate and potassium magnesium sulfate, produced for special crops, comprised about one-sixth of the potash production. Potash was distributed by train, truck, and barge to warehouses, wholesalers, and retailers. Retailers sold both potash and potash blended with other fertilizers in dry or liquid forms for distribution over the fields in both spring and fall.

2. SALIENT STATISTICS -- UNITED STATES

Potash (Data in thousand metric tons K_2O equivalent:

	1979	1980	1981	1982	1983[e]
Production: Marketable	2,225	2,239	2,156	1,784	1,300
Imports for consumption	5,165	4,972	4,796	3,858	4,200
Exports	635	840	491	519	350
Apparent consumption	6,918	6,349	6,213	5,123	5,170
Price (average annual): Muriate, dollars per metric ton of K_2O, f.o.b. mine[1]	$95	$130	$137	$109	$110
Stocks: Producer, yearend	251	273	520	520	500
Employment: Mine	1,800	1,800	1,830	1,620	1,100
Mill	1,450	1,450	1,400	1,140	930
Net import reliance[2] as a percent of apparent consumption	66	65	65	65	75

e Estimated.

1 Average prices based on actual sales, excluding soluble and chemical muriates.

2 Defined as imports - exports + adjustments for Government and industry stock changes.

3 Reserves in the Dead Sea.

Prepared by [J.P. Searls], telephone number (202) 634-1190.

3. RECYCLING

None.

4. IMPORT SOURCES (1979-82)

Canada 93%, Israel 5%, Other 2%.

5. TARIFF

	Number	Most Favored Nation (MFN)		Non-MFN
		1/1/84	1/1/87	1/1/84
Potassium chloride	480.50	Free	Free	Free
Potassium sulfate	480.55	Free	Free	Free
Potassium fertilizers/ fertilizer materials	480.75	Free	Free	Free

6. DEPLETION ALLOWANCES

14% (Domestic), 14% (Foreign).

7. GOVERNMENT STOCKPILE

None.

8. EVENTS, TRENDS, AND ISSUES

Demand for potash in the United States increased about 1% in 1983 compared with that of 1982 but was still nearly 17% below that of 1981. Production in 1983 decreased about 27% compared with the 1982 level. The payment-in-kind program, low farm earnings, and high interest rates reduced demand for fertilizer. One domestic potash plant closed until potash prices rise significantly, while a near-surface brine operation closed temporarily because rain flooded its gathering trenches. Most other plants either shut down for long summer vacations and maintenance or operated on reduced work schedules.

Exports decreased about 33% while imports increased about 9% compared with those of 1983. Exports fell, primarily due to the strong U.S. dollar and the reduced levels of Brazilian, Indian, and Japanese imports. Significant quantities of Canadian potash were loaded at Thunder Bay, Ontario, for lake freightage to Burns Harbor, Indiana; Toledo, Ohio; and Baltimore, Maryland. Imaginative efforts by Canadian potash producers in reducing transportation costs to U.S. markets have increased their market share. The size of the market remaining for the domestic producers relative to their capacities has become a problem.

The U.S. Department of Labor, Mine Safety and Health Administration released its preproposal draft concerning "Metal-Nonmetal Standards, Section 21-Gassy Mines," which presented a five-level gassy mine categorization system. Category placement is by (1) the history and geology of the province and the mine; (2) the nature of the ore body and the host rock; and (3) the character of methane gas emission (if any). Under the old two-level standards, two Carlsbad, New Mexico, mines were under threat of being declared "gassy" and forced to convert to "permissible" technology and operations. The capital cost of this conversion could have put the mines out of business. Under the new standards, the potash mines probably would be rated at the lowest levels of gas presence, which would require small additional costs to the companies.

It is estimated that in 1984 domestic mine production of potash will be 1.7 million tons and U.S. apparent consumption will be 5.9 million tons. From a 1981 base, demand for potash is expected to increase at an average annual rate of 2.2% through 1990.

9. WORLD MINE PRODUCTION AND RESERVE BASE

	Production		Reserve Base*
	1982	1983[e]	
United States	1,784	1,300	300,000
Canada	5,196	5,500	45,000,000
France	1,823	1,750	60,000
Germany, Federal Republic of	2,500	2,500	600,000
Israel/Jordan	1,010	1,300	300,000[3]
Italy	160	160	12,000
Spain	690	690	75,000
United Kingdom	240	280	75,000
Other Market Economy Countries	22	20	200,000
China	25	25	200,000
German Democratic Republic	3,500	3,500	1,000,000
U.S.S.R.	9,000	9,000	3,800,000
World Total	25,950	26,000	51,600,000

10. WORLD RESOURCES

Estimated domestic potash resources total about 6 billion tons. Most of this lies between 6,000 and 10,000 feet deep, in a 1,200-square-mile area of Montana/North Dakota as an extension of the Williston Basin deposits in Saskatchewan. The Paradox Basin in Utah contains approximately 2 billion tons, mostly at depths of more than 4,000 feet. About two-thirds of the world's resources are located in Saskatchewan. Most of the North American

* Pending establishment of criteria for the reserve base, classification of data is based on a judgmental appraisal of current knowledge and assumptions.

3. RECYCLING

None.

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resources are recoverable only by solution mining techniques because they are found at depths greater than 3,500 feet. Estimated world resources total about 250 billion tons. The potash deposits in the U.S.S.R. are the bulk of the Centrally Planned Economy countries' resources. Very large resources, about 10 billion tons and mostly carnallite, occur in Thailand. Significant resources occur in the German Democratic Republic and the Federal Republic of Germany.

11. SUBSTITUTES

There are no substitutes for potash as an essential plant nutrient.

PART II: CALIFORNIA

12. CALIFORNIA GEOLOGICAL OCCURRENCES

Sources of potassium compounds in the United States and elsewhere in the world are of two main types: (1) crystalline deposits of saline rocks of marine origin containing sylvite, langbeinite, and related potassium minerals, and (2) concentrated brines from wells or in relict lakes and lacustrine sediments of continental origin in arid regions. The crystalline deposits are by far the richest in potassium and the simplest to exploit. The concentrated brines are lower grade but generally allow production of other substances such as sodium carbonate, sodium sulfate, borates, magnesium, lithium, or bromine as coproducts of the potassium compounds along with the potassium salts so that the costs of processing are shared, a practice that contributes to the commercial feasibility of such low-grade sources of the element. In other respects, however, brines that yield potassium have little else in common, either geologically or chemically. Production from California is from alkaline, near-surface brines in an upper Quaternary saline deposit (Searles Lake); Utah production is from nearly neutral surface waters of a saline lake; Michigan production is from acidic deep-well brines (Smith and others, 1973).

Searles Valley is a closed structural basin filled with alluvium and non-marine evaporites. Thickness of the fill ranges from 0 at the periphery to over 900 m in the deeper portions, as shown by geophysical studies and by one well, KM-3, drilled to a depth of 930 m in 1968 by Kerr-McGee. Basement rock is a quartz monzonite, which also is the major rock type in the Argus and northern Slate ranges. The evaporite deposit of Searles Lake consists of alternating mud beds and brine-saturated salt beds. Evaporite beds are generally thicker at the lake center, becoming thinner and pinching out toward the lake's periphery. These beds were formed under conditions of evaporation while the lake was a mere salt pan. The mud beds, however, were formed during full lake conditions and become thicker toward the lake periphery, grading into coarse, clastic sediments at the base of the mountains (Moulton, 1980).

The salt beds in general are brine saturated, white to pink in color, hard and very porous. The important chemical ions are Na+ (sodium), K+ (potassium), CO_3 (carbonate), HCO_3 (bicarbonate), SO_4 (sulfate), Cl- (chloride), and B_4O_7 (borate). These ions are present in the brines in various concentrations and have combined to form the following minerals: halite, hanksite, trona, nahcolite, burkeite, borax, thenardite, sulfohalite, and glasurite (Moulton, 1980).

The mud beds in general are dark green to brown, soft, impervious, and may have a distinct mercaptan (rotton eggs) odor. The important chemical ions in the mud are CA++ (calcium), Na+ (sodium), Mg++ (magnesium), and CO_3 (carbonate), which have precipitated as fine-grained aragonite and dolomite, and as fine and coarse-grained gaylussite and pirssonite. The surface mud bed also contains clay-sized halite and coarse borax and hanksite locally (Moulton, 1980).

13. CALIFORNIA LOCALITIES

The Searles Lake deposit, located in San Bernardino County, is California's only current producer of potassium compounds (Figure 1). The geologic history of Searles Lake is complex; however, geologists agree that Searles Lake was the site of several large lakes during the Pleistocene approximately 10,000 to 130,000 years ago. Nourished by glacial meltwaters from the eastern slopes of the Sierra Nevada, Searles Lake was part of a chain of lakes that extended from Mono Lake (Lake Russell) into Panamint Valley. Searles Lake, because of its basin configuration, reached the greatest depth and areal extent and became a repository for dissolved minerals. Evaporation of the glacial meltwater left behind a deposit of over three billion tons of soluble mineral salts concentrated into a dense, alkaline brine containing 98 of the 104 known chemical elements (Kerr McGee, 1982).

Owens Lake, in Inyo County, recorded minor potash production in conjunction with a sodium carbonate operation until the late 1960's when high runoff into the lake closed the operation. However, before its desiccation, Owens Lake contained principally carbonates, sulfates, and chlorides. The lake bed now contains a porous, brine-filled crystal body similar to that at Searles Lake but with a maximum thickness of only 9 feet. Both the crystal body and brine are higher in soda content and lower in potash (average brine contains 2-3% KCL) content than Searles Lake (Ver Planck, 1957).

Many of the basins in California that now contain playas held lakes in Quaternary time, but crystal bodies are believed to have formed only in those basins that received the clarified drainage of a large area for a long time. Thus, basins like Bristol Lake, Cadiz Lake, Dale Lake, Danby Lake, and the Salton Sea, although containing sodium compounds, have little probability of containing crystal bodies capable of sustaining economic production of accessory potassium compounds (Ver Planck, 1957).

California contains numerous geothermal fields, and although relative abundance of potassium compounds in geothermal fluids has been documented, extraction of these compounds would be dependent upon the economic feasibility of geothermal power production. Two areas, the Coso Geothermal Field and the Imperial Valley Geothermal Field, potentially are candidates for potassium compound extraction prior to reinjection of geothermal fluids.

14. CALIFORNIA PRODUCTION

Although potassium was identified as a major component of the Searles Lake brine-salt complex in 1898, its commercial significance was not recognized until about 1912. American requirements for potash up to World War I were based entirely on imports, primarily from Germany. During World War I, Searles Lake became the sole American source of potash, and it retained this position until the New Mexico potash deposits were developed in the early 1930's.

Potash production from Searles Lake in 1915 was 250 tons. In 1916, this increased to 36,000 tons, all from the American Trona Corporation and the Borosolvay operations. Subsequent expansion by the successors to the American Trona Corporation, American Potash and Chemical Corporation,

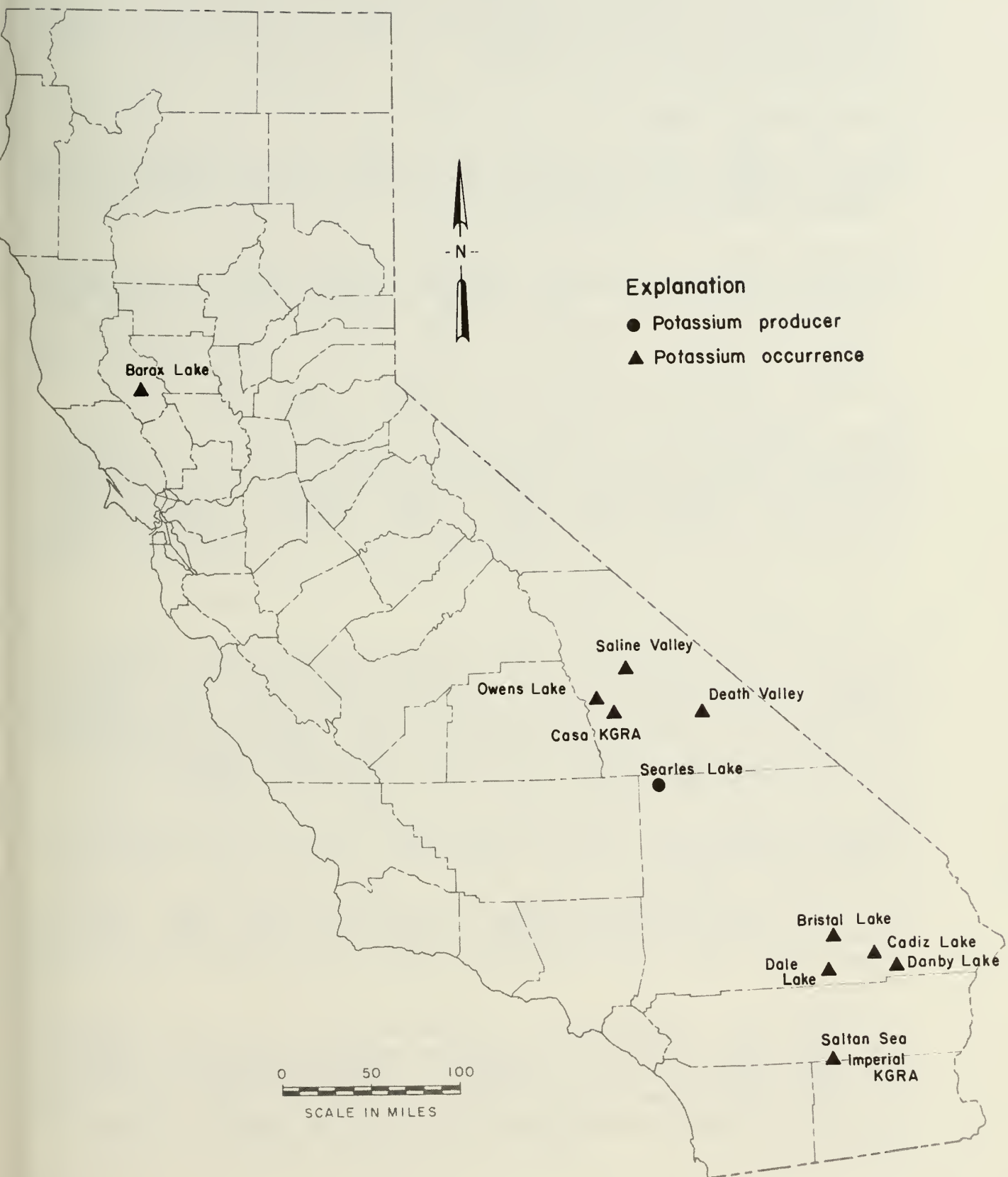
N
Explanation
Potassium producer
Potassium occurrence
Borax Lake
Saline Valley
Owens Lake
Death Valley
Casa KGRA
Searles Lake
Bristal Lake
Cadiz Lake
Danby Lake
Dale Lake
Salton Sea
Imperial KGRA
0
50
100
SCALE IN MILES

FIGURE 1

raised potash production from Searles Lake to 100,000 - 300,000 tons annually (Kerr-McGee, 1980). Current potash production by Kerr-McGee at Searles Lake is considered propietary, but the above-quoted tonnages are representative. In 1982 Kerr-McGee produced two potash products: muriate (62% K_2O) and potassium sulfate (50% K_2O). Production of muriate predominated the product distribution.

15. UTILIZATION AND MARKETS

The two potash products produced at Searles Lake are marketed locally within California and nationally within the U.S. A minor percentage goes into the international export market.

In 1983, utilization of produced potassium chloride (muriate) was dominated by fertilizer use at 70%; the remaining 30% was divided between several industrial applications. The foremost industrial application was as a drilling mud additive (potassium replaces sodium within clay lattices and prevents swelling in drillholes), and with minor applications in high temperature solutions utilized in the fabrication of metal alloys, particularly aluminum (Stan Fletcher, Kerr-McGee, personal communication).

Market distribution of potassium sulfate in 1983 was almost wholly in fertilizer application (90%) with minor secondary industrial applications. Although potassium sulfate is produced only at two U.S. locations (Great Salt Lake is the other one) and is a common industrial chemical, most of California's production went into the gypsum wallboard industry at Plaster City where it is used as a moisturizing agent and drying retardant (Stan Fletcher, personal communication).

16. MINING METHODS AND BENEFICIATION*

The source of all the plant feeds for Kerr-McGee Chemical's Searles Lake operations are brine-bearing salt beds in Searles Lake. These brines are produced from the salt structures by a system of pipelines and wells for each plant. The systems are designed to produce the best brine available for the plant it supplies. In some cases, solar ponds are used to concentrate the brine so that plant efficiency will be greater.

The Westend plant uses Lower Salt with minor Mixed Layer and Upper Salt brine normally pumped directly to the plant. Some solar concentration is used in the summer months.

The Trona plant complex used Upper and Lower Salt brines that have been solar concentrated, either directly from ponds in the summer time or in the winter months from an area where solar pond brine has been stored in the Upper Salt.

The Argus plant is supplied from a system of wells in the A and B zones of the Mixed Layer. This system includes not only pumping wells and pipelines but also injection wells and pipelines. Artificial recharge is needed in the Mixed Layer system because, unlike the Upper and Lower Salts, these beds are too deep to be recharged by the return of effluent onto the lake surface.

---

* From Moulton, 1980.

TRONA MAIN PLANT CYCLE

The main plant cycle consists of three major process plants. These are the potash plant, the borax plant, and the salt cake plant (Unit 400). Brines from the lake are first cooled in the Unit 400 process where glauber salts are removed to produce salt cake. Cooled brine is heated by incoming lake brine in heat exchangers. Desulfated brine from Unit 400 then goes to the evaporators where water is removed by heating and NaCl is removed by crystallization. The potash plant receives the hot concentrated liquor from the evaporators, which is cooled to crystallize KCl. The cooled liquor from the potash plant is fed to the borax plant, where it is cooled further, and borax is crystallized. The end liquor from the borax plant is mixed with the brine stream feeding the evaporators.

Parts of the KCl solids and high potash liquors are used to produce K_2SO_4 in a secondary plant. Another secondary plant reacts borax with H_2SO_4 to produce boric acid.

TRONA LLX-BAX-PLANT

Low quality lake brine is feed for the LLX-BAX process plant. The boron values are extracted from the brine into an organic extractant, which complexes the boron values as a sodium and/or potassium species. Boron, sodium, and potassium values are then extracted into a dilute sulfuric acid solution, which is evaporated and crystallized to produce boric acid and mixed sodium and potassium sulfates. These mixed sulfates are then fed to the K_2SO_4 plant.

17. CALIFORNIA EVENTS, TRENDS, AND ISSUES

California's sole producer is affected by the issues discussed in Section 8 relative to the United States as a whole. Kerr-McGee Chemical Corporation began closing its 60-year-old Trona plant in April 1982, and laid off nearly 500 employees. High energy costs were blamed for the closure although depressed markets for potash, sulfate, and boric acid contributed to the problem. The company's neighboring plants (Argus and Westend) will continue production at reduced rates for anhydrous borax and boric acid; output of sulfate is to remain at the level of previous years (U.S. Bureau of Mines, 1982). In addition, curtailment or a decrease in potassium production from the brine operation on Utah's Great Salt Lake due to abnormally high spring runoff and high lake water levels, could have the effect of increasing demand for the potassium compounds produced at the Searles Lake operation and thus give Kerr-McGee a larger share of the market.

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